Accounting for Crosslinguistic Variation:
A Constraint-Based Perspective

Robert Thornton, Mariela Gil, and Maryellen C. MacDonald
Department of Psychology
University of Southern California

Much of the research on sentence processing has focused on discovering universal principles to explain parsing preferences. Recent cross-linguistic work, however, suggests that processing is sensitive to distributional information about individual languages. Along these lines, we explore a constraint-based approach to processing, in which cross-linguistic variation is explained by the interaction of language specific grammatical constraints with more general pragmatic principles. Specifically, we examine the role of pragmatic information in constraining the modification of complex noun phrases in English and Spanish. We first present data suggesting that, for both languages, initial comprehension is constrained in the same manner by pragmatic information. We then pursue an explanation of cross-linguistic differences in terms of pragmatic constraints on grammatical differences between the languages.

Comrie (1989) makes a distinction between two different approaches to cross-linguistic research. The first approach follows from the work of Greenberg, who attempted to establish descriptive grammatical universals by examining a wide array of languages. These universals are stated in terms of concrete properties of language, for example "all languages have pronominal categories involving at least three persons and two numbers" (Greenberg, 1963, p. 96). According to this approach, the job of the researcher is to compile a descriptive, theory-independent database of a representative sample of the world's languages and then to formulate concrete universals on the basis of general tendencies among the languages.

Alternatively, Chomsky's early work stressed the need to look at a few languages in great depth. While acknowledging "a great diversity in the surface structure of languages" (Chomsky, 1965, pp. 118), this approach focuses on universals that are stated in terms of fairly complex abstract knowledge about grammatical relations and generalizations. Accordingly, Chomsky (1965, p. 118) notes:

There is no reason to expect uniformity of surface structures, and the findings of mod-

ern linguistics are thus not inconsistent with the hypotheses of universal grammarians. Insofar as attention is restricted to surface structures, the most that can be expected is the discovery of statistical tendencies, such as those presented by Greenberg (1963).

Within this framework, universal grammar is thought to be innate and consequently independent of any particular language. Therefore, the focus of this program of research has been deep analysis of a relatively small number of languages in the hope of discovering the relationship between surface structure and its underlying grammatical basis, rather than broad typology, which would, according to this view, only indicate how languages differ from each other.

Although both of these perspectives have stressed the need for linguistic analysis resulting in the formulation of general principles, they differ in two fundamental ways: (a) the nature of the data needed for analysis (i.e., the number of languages studied) and (b) the abstractness of the proposed universals. In the following section, we discuss parallels to this distinction in recent psycholinguistic research and outline a number of current theories of sentence processing. We then present relevant cross-linguistic data on modifier attachment in English and Spanish. These data suggest several conclusions concerning the role of cross-linguistic data in forming theories of sentence processing.

Psycholinguistic Approaches to Cross-linguistic Variation

Garden-Path Theory

Principle-based accounts of parsing propose that the assignment of syntactic structure is initially guided solely by abstract structural principles. Although a number of researchers have proposed such accounts of parsing (Berwick & Weinberg, 1984; Gibson, Pearlmutter, Canseco-Gonzalez, & Hickok, 1996; Gorrell, 1989; Hawkins, 1994; Pritchett, 1988, to name a few), we will focus on the best known of these: garden-path theory (De Vincenzi & Job, 1995; Ferreira & Clifton, 1986; Frazier, 1987; Frazier & Rayner, 1982; Rayner, Carlson, & Frazier, 1983). This theory proposes a parser that constructs a single syntactic representation according to the phrase structure rules of a given language. Given a choice between alternative structures, parsing is initially governed by two general principles: (a) *late closure*, which directs the parser to attach new material into the phrase currently being processed rather than to a more distant attachment site (Frazier & Rayner, 1982); and (b) *minimal attachment*, which directs the parser to construct the simplest syntactic structure consistent with the input (Rayner et al., 1983). These principles are motivated by the need to quickly structure information in memory (i.e., a simple syntactic structure should be easier to construct than more complex ones). Frazier (1987) has suggested that because these abstract principles are non-arbitrary extensions of general processing constraints, they are universal. In this respect, this program of research echoes the Chomskyan program, in that rather than attempting to catalog concrete differences between languages, several general abstract principles are said to govern processing universally.

Although late closure and minimal attachment predict no cross-linguistic differences in initial processing, a number of recent studies provide data suggesting that the local attachment preference taken as evidence for late closure does not hold for all languages (see Mitchell & Brysbaert, this volume, for review). Frazier and Clifton (1996, 1997) have recently proposed that late closure and minimal attachment are indeed universal, but apply only to the processing of *primary phrases*, which are, for the most part, the main subject-predicate and all of its obligatory arguments. A *non-primary phrase* is one that cannot, even temporarily, be considered primary (e.g. relative clauses,

adjunct predication, conjoined phrases). Nonprimary phrases are handled by *construal*, a mechanism that associates incoming material into the *current thematic processing domain*, using a variety of structural and nonstructural information. Thus, cross-linguistic variation in initial interpretation is predicted *only* in the nonprimary cases, whereas primary phrases should still universally conform to late closure and minimal attachment.

In a recent series of questionnaire studies on relative clause (RC) attachment to complex noun phrases (NPs) in English and Spanish, Gilboy, Sopena, Clifton, and Frazier (1995), presented data in support of construal. They found that attachment preferences for ambiguous RC modifiers were mediated by nonstructural information, specifically the thematic and referential properties of the NPs. They reported a striking similarity *between* the languages while finding a large amount of variation *within* each language. Following Frazier (1990), they proposed a Gricean account of cross-linguistic variation to explain the differences found between the languages, which we will discuss in greater detail in a later section.

Statistical Tuning

In contrast to garden-path theory, which posits universal, abstract parsing principles, *the tuning hypothesis* (Cuetos, Mitchell, & Corley, 1996; Mitchell, Cuetos, Corley, & Brysbaert, 1995) invokes an experience-based parsing mechanism that is sensitive to information about the frequency distributions of different structural possibilities. On this view, tuning occurs at a purely structural level, on the basis of syntactic category information; all lexical influence is initially ignored. This limitation in sensitivity to statistics concerning only structural information is thought to owe to memory limitations (Mitchell et al., 1995). Accordingly, when comprehenders are faced with a structural ambiguity in their language, the preferred resolution of the ambiguity will have the structure that they have most frequently been exposed to; structural processing preferences are determined by the frequency with which they occur in a particular language. Consequently, tuning predicts that a comprehender's parsing preferences should highly correlate with phrasal-level statistical patterns found in various corpora. Cross-linguistic variation is explained by differing frequency distributions in different languages. This approach most closely echoes the Greenbergian program, in that theorizing occurs at a relatively concrete level of description; no abstract constraints are proposed and initial parsing decisions are based exclusively on a person's exposure to statistical distributions of structural information.

As Cuetos et al. (1996) note, although tuning does not propose any specific universal parsing principles, it does place universal constraints on parsing; the suggestion is that what is universal is a frequency sensitive processing mechanism that is capable of attending to the phrasal-level structural regularities of a particular language, rather than being directed by abstract parsing algorithms. In summary, Tuning makes the relatively straightforward prediction that initial parsing decisions are predictable solely from overall structural patterns in the language.

Constraint Satisfaction

Both the principle-based and statistical accounts outlined so far posit that the processing mechanism initially makes use of a very limited domain of information. For garden-path theory, this information concerns the syntactic category of each word in the input. For tuning, it is information regarding the frequency of occurrence of different structural possibilities. Both models propose that the influence of all other sources of constraint are limited to a secondary reanalysis stage. By

contrast, constraint-based models propose that a number of sources of information are initially relevant to sentence comprehension; furthermore, there are no architectural limitations to the use of certain kinds of information, as in the theories discussed above. On this view, some constraints may affect sentence interpretation earlier than others, but these effects may be traced to (a) distributional information, such that more local and frequent information has a larger influence than other constraints, and (b) architectural properties of the cognitive system, such as the nature of activation and competition mechanisms (McRae, Spivey-Knowlton, & Tanenhaus, in press). Thus the focus in these models has not been on the initial influence of a single source of information; rather, these models have critically examined the integration and time-course of a number of constraints that are available early in processing (Boland, Tanenhaus, & Garnsey, 1990; Garnsey, Pearlmutter, Myers, & Lotocky, 1997; MacDonald, Pearlmutter, & Seidenberg, 1994; Spivey-Knowlton & Sedivy, 1995; Trueswell, Tanenhaus, & Garnsey, 1994).

Although much of the recent constraint-based work has focused on the influence of lexical information on syntactic ambiguity resolution (MacDonald, 1994; Trueswell, 1996), these models in fact propose three broad levels of constraint (MacDonald et al., 1994; Spivey-Knowlton & Sedivy, 1995): (a) Lexical: in understanding sentences, comprehenders must recognize individual words, making fairly detailed semantic and frequency information available from the individual lexical items (Garnsey et al., 1997; MacDonald et al., 1994; Trueswell et al., 1994). (b) Structural: word order and processing constraints result from the serial order of language (see Hawkins, 1994; Weckerly & Elman, 1992, for examples). Additionally, the processing mechanism is sensitive to a number of types of contingent frequency information (Juliano & Tanenhaus, 1994). (c) Pragmatic/discourse: as each word is being integrated with the rest of the input, a higher levels discourse representation of the utterance begins to form, which in turn acts as a top-down source of constraint on processing (Altmann & Steedman, 1988; Spivey-Knowlton & Sedivy, 1995).

In other words, like tuning, these models predict that the processing mechanism is sensitive to the contingent frequencies of different structural alternatives in the input (Juliano & Tanenhaus, 1994) and as a result ambiguity resolution may differ cross-linguistically. Unlike tuning, however, these models predict that the frequencies of structural patterns are only one of a number of sources of soft constraint on initial processing; processing is mediated by lexical and pragmatic/discourse information as well. In the next section, we discuss cases in which cross-linguistic variation is constrained by a broad pragmatic constraint: the felicity of NP modification.

Pragmatic Constraint on Cross-Linguistic Variation

Much of the recent cross-linguistic research on sentence processing has focused on word order, specifically on modifier attachment to complex NPs. Part of the reason that this has been such an active area of research is that although a number of languages share these types of ambiguities, different languages seem to resolve them in different ways (see Mitchell & Brysbaert, this volume, for review). For example, Cuetos and Mitchell (1988), among others, have found that for sentences like (1), Spanish speakers preferred to attach the RC to the more distant of two NPs, such that subjects interpreted the daughter, rather than the colonel, as having the accident. Given comparable English materials, however, English speakers preferred to attach the RC to the local NP, with the interpretation that it was the colonel who had the accident.

(1)   La hija del coronel que tuvo el accidente
      'The daughter of the colonel who had the accident'

Garden-path theory predicts that the initial interpretation of complex NPs is governed by abstract, innate, universal parsing principles. Tuning predicts that initial interpretation is governed simply by exposure to the structural patterns of the language. We, however, propose a constraint-based model of cross-linguistic variation in which exposure to the statistical distributions (at structural and other levels) of one's language interacts with more general pragmatic constraints guides initial comprehension. Accordingly, there may be differences between languages in initial attachment preference owing to different distributional properties, but any such differences should be mediated by other sources of constraint that operate in the same manner for all languages. We hypothesize that certain pragmatic constraints hold cross-linguistically and are a major limitation on the degree of cross-linguistic variation that is observed in attachment to complex NPs.

We have recently conducted several experiments that illustrate the importance of pragmatic constraint in resolving structural attachment ambiguities (Thornton, MacDonald, & Gil, 1998). In two self-paced reading experiments, we examined modifier attachment to complex NPs in English and Spanish in structures of the form *NP1 prep NP2 (prep NP3)*, where the material in parentheses could modify either NP1 or NP2. We manipulated a broad pragmatic constraint that we hypothesized to hold cross-linguistically, the felicity of NP modification. Modifiability, in this sense, refers to the amount of information that a comprehender needs to uniquely identify entities in the input. For example, in (2a), the head of NP2 has received strong modification in the sense that a particular hall is identified, whereas in (2b), it has received weak modification in the sense that the focus operator *only* sets up a contrast set of a number of halls and more modification is needed to uniquely identify a particular hall.

(2)   a.   The computer down my front hall with...

      b.   The computer down the only hall with...

Similarly, the head of NP2 is more strongly modified in (3a) than in (3b) because the use of the possessive pronoun *our* selects a single, specific referent for *red car*, as people generally only have a single red car. Although the definite determiner *the* in (3b) presupposes a unique referent (see Hawkins, 1991; Kadmon, 1990, for discussion of uniqueness), it is not infelicitous to add additional modification in order to select a specific red car from a number of other ones.

(3)   a.   The mechanic by our red car with...

      b.   The mechanic by the red car with...

Following work that stresses the importance of this kind of pragmatic constraint on processing (Altmann & Steedman, 1988; Spivey-Knowlton & Sedivy, 1995), we predicted that as the modification of a noun becomes stronger, that is, identifying it more uniquely in the discourse, it is less likely to receive further modification. Neither tuning nor garden-path theory predict a difference between the initial processing of (2a) and (2b) or (3a) and (3b); tuning predicts that processing initially occurs without reference to this sort of pragmatic constraint and garden-path theory predicts that sensitivity to pragmatic factors applies only to the processing of nonprimary phrases, such as relative clauses, but not to primary phrases, such as the prepositional phrase (PP) modifiers used in our experiments.

We constructed 32 sentences of the type in (2) and (3) with endings that pragmatically disambiguated the PP as either modifying NP1 or NP2, as in (4).

(4)   a.   NP1 modifying disambiguation:
            The computer down the only hall with expanded memory.
      b.   NP2 modifying disambiguation:
            The computer down the only hall with a drinking fountain.

We presented these items in counterbalanced fashion to 48 native English speakers in a self-paced reading task. Twenty-eight comparable Spanish items were also presented to 40 native Spanish speakers in the same task. We examined reading times at the disambiguation and subsequent words and found overall cross-linguistic differences in initial attachment preference between the English and Spanish speakers: English speakers exhibited a greater overall preference for local (NP2) attachment than Spanish speakers did, replicating previous findings (see Mitchell & Brysbaert, this volume, for review). In both languages, however, subjects' preferences were mediated by the modifiability of NP2. Specifically, when modification to the head of NP2 was weak, English subjects' reading times were longer at a disambiguation phrase that promoted NP1 modification than for one that promoted NP2 modification, whereas Spanish subjects showed no significant differences across disambiguation type. In other words, in the weak modification condition, which promotes NP2 attachment, English speakers exhibited an NP2 attachment preference, while Spanish speakers exhibited no clear attachment preference. When the head of NP2 had received strong modification, promoting NP1 attachment, however, English subjects showed no significant differences across disambiguation type, while Spanish subjects' reading times were significantly longer for the NP2 attachment disambiguation than for the NP1 attachment disambiguation. This pattern of reading times demonstrates the very early effect of this pragmatic constraint for both languages: As modification to the head of NP2 becomes stronger, additional NP2 modification becomes infelicitous, and attachment to NP1 becomes more likely. Thus, we can see that this type of pragmatic information, NP modifiability, constrains the range of cross-linguistic variation insofar as it has a similar effect on attachment preferences in both English and Spanish. Modifiability, however, does not explain the overall stronger tendency for local (NP2) modification in English than in Spanish. We hypothesize that the overall difference in modification preferences emerges from variations in the use of alternative syntactic structures in English and Spanish, which we discuss in the next section.

The Case of Word Order and Genitives

In some respects, our explanation of the overall differences between the English and Spanish data is similar to the Gricean argument put forth by Frazier (1990) and elaborated by Frazier and Clifton (1996). There are a number of constructions that have acceptable alternatives in English but not in Spanish. For example, English has two types of genitives: prepositional (e.g., *the dress of the singer*) and prenominal (e.g., *the singer's dress*), whereas Spanish (and romance languages in general) has only prepositional genitives (e.g., *el vestido de la cantante*). Part of our explanation for the overall preference for local (NP2) modification in English relative to Spanish stems from the fact that a number of different structural options for noun modification are frequently used in English, whereas only one is available in Spanish for the structures in question. We argue that the availability or non-availability of alternative structures constrains interpretation of ambiguous modifiers.

Consider first the situation in English, with its two alternative modification forms. The choice of one versus the other form can have a substantial effect on what kinds of postnominal modification are grammatical. For example, if a speaker chooses a prenominal genitive such as *the singer's*

dress, further postnominal modification of *dress* is allowable, as in *the singer's dress with gold sequins*, but further modification of *singer* is not permitted (e.g., **the singer's dress with a lovely voice*). In order to further modify the singer, the prepositional genitive must be used (e.g., *the dress of the singer with the lovely voice*). Thus use of the prepositional genitive is obligatory when NP2 modification is desired, and we suggest that these grammatical constraints create frequency asymmetries in English, such that there is frequent use of the prepositional genitive (i.e., *NP1 prep NP2*) with NP2 modification in English. We suggest that the resulting frequency distributions of form-meaning pairs, which can be traced to these grammatical constraints, are a major factor in the general NP2 modification preference that is observed in English for *NP1 prep NP2* structures. By contrast, Spanish has no alternative prenominal genitive, so the *NP1 prep NP2* structure must be used in all cases, no matter what additional modification might be desired. Thus there is no strong association between a particular genitive form and particular modification in Spanish, and therefore no overall NP2 modification preference for *NP1 prep NP2* structures in Spanish.

Interestingly, there are a set of relations for which the prenominal genitive is not allowed in English, and the prepositional *NP1 prep NP2* form is required. In prepositional phrases in which the preposition conveys a thematic role, a prenominal form is not a grammatical option. This pattern is illustrated in (5); in attempting to express the prepositional modifier in (5a) as a prenominal modifier in either (5b) or (5c), all semantic and thematic content of the preposition *near* is lost.

(5) a. the farmer near the barn

b. *the barn's farmer

c. *the barn farmer

In other words, locative relationships as in (5) and other relationships in which the preposition conveys a particular thematic role must always be expressed in the prepositional structure in English, regardless of what kind of further modification might be needed. Thus there is likely to be no strong association between the use of the prepositional structure and a particular modification site. The locative case in English therefore mirrors the situation with all prepositional phrases in Spanish. By contrast, possessive relationships in English, in which the preposition *of* conveys no thematic role, may be expressed in two structures in English, but the use of these structures is limited by the type of modification that the speaker intends, resulting in large frequency asymmetries in the pairings of particular structures with modifications. We have predicted a relationship between the availability of alternative structures and interpretation preferences of ambiguous modifiers cross-linguistically, and the same availability predictions should hold within a language as well. Specifically, for English, modification of NP2 in a *NP1 prep NP2* sequence should be strongly preferred when the sequence conveys a possessive relation, as the *NP1 of NP2 (NP2 modifier)* sequence is very frequent in English, owing to constraints on the use of the prenominal genitive alternative structure. For locative relationships, however, for which the same structure must be used independent of modification, we predict that there will not be a strong preference for NP1 or NP2 modification.

We have recently collected off-line data that test this prediction. English speakers wrote completions for complex NPs with the structure *NP1 prep NP2 PP* or *NP1 prep NP2 RC*. We manipulated the type of complex NP so that it expressed either a possessive relationship or a locative relationship. We also manipulated whether the last word of the fragments introduced a relative clause (either *that* or *who*) or a prepositional phrase (*with*). We predicted that subjects will prefer low attachment completions for the possessive NPs, which can be expressed with an alternative

structure, than for the locative ones, which cannot. We further predicted that the availability of this type of information will affect the attachment of RC and PP modifiers in a similar manner.

By contrast, the construal hypothesis (Frazier & Clifton, 1996) makes very different predictions for interpretation of these items. Because PPs are possible primary relations, the attachment of the PP items should be governed by late closure, leading to an NP2 interpretation preference for all items, independent of their possessive or locative status. Relative clauses are non-primary phrases, however, so interpretation of these items should be governed by construal. Thus the RCs are predicted to be associated into the current thematic processing domain, which Frazier and Clifton (1996) define as the maximal projection of the last theta assigner. Because the prepositions in the locative items are theta assigners, only one site (NP2) is open for modification, whereas both NP1 and NP2 are open for the possessive items, as *of* only assigns case, and not a thematic role. As a result, construal predicts that for RC attachment, NP2 modification should be strongly preferred for the locative items and less so for the possessive items.

Method

Subjects

Sixteen University of Southern California undergraduates were paid for participation. All were native English speakers.

Materials

Twenty-four ambiguous sentence fragments of the structure *NP1 prep NP2 with/who/that* were used. There were two experimental manipulations. First, the relationship between NP1 and NP2 was either locative or possessive. For the locative condition, all NPs were inanimate. Three items were constructed for each of the four locative prepositions used: *behind*, *beneath*, *beside*, and *near*, for a total of twelve locative items. For the possessive condition, all NPs were animate. Six items each were taken from the kinship and functional items (types B1 and B2, respectively) used by Gilboy et al. (1995), for a total of twelve possessive items. Second, the last word of the fragment either introduced a PP (*with*, in all cases) or an RC (*who* for the 12 animate items and *that* for the 12 inanimate items). See (6a) for example of a possessive-relation NP and (6b) for an example of a locative-relation one.

(6) a.   The assistant of the inspector with/who

  b.   The table near the window with/that

Procedure

Stimuli were presented on paper in random order. Two presentation lists were created containing an equal number of items from each condition, with each item appearing only once in each list. Two practice items of the same structure were composed. Subjects were asked to complete the sentence fragments with the first thought that came to mind. Following completion of the questionnaire, the experimenter, who was blind to the hypotheses, reviewed the questionnaire with the subject and asked, for each item, which person or object was modified by the subject's written completion. The entire procedure took about 10 minutes.
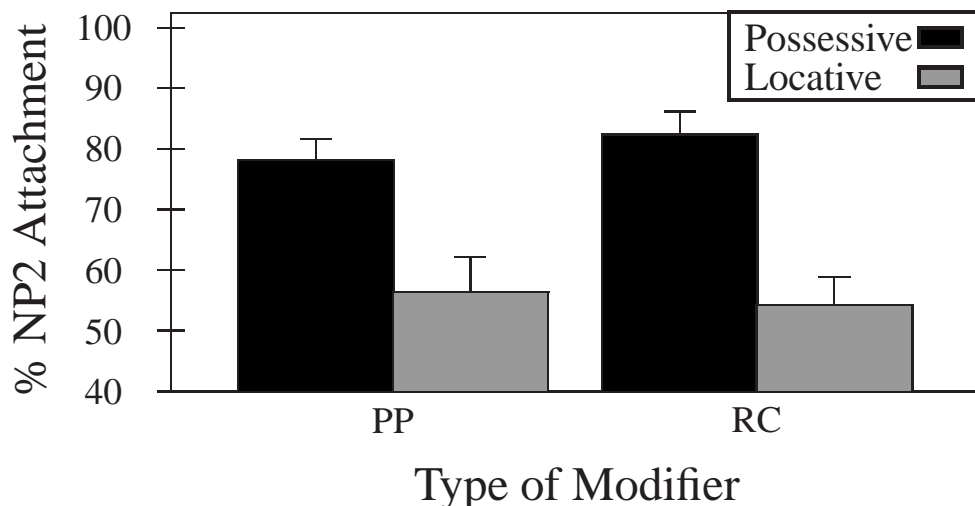
Figure 1. Percentage NP2 attachment to complex NPs containing locative or possessive modification

Results and Discussion

The sentence completion data are presented in Figure 1. Overall, 68.75% of the completions indicated attachments to NP2, consistent with a number of other studies that found a local attachment preference in English (Cuetos & Mitchell, 1988; Gibson et al., 1996). There was a main effect of the type of relationship between NP1 and NP2, $F_1(1, 15) = 20.38, p < .001$, $F_2(1, 22) = 22.63, p < .001$, such that subjects were more likely to modify NP2 for the possessive items than for the locative items. There was no main effect of the type of modifier, and the interaction of these variables was not significant, all $Fs < 1$.

These data support both of our predictions and run counter to the construal hypothesis in several important ways. First, the possessive items, which have an acceptable alternative form, yielded more NP2 completions than did the locative items, which have no acceptable alternative forms. This result demonstrates that information about the availability of alternative structures has a robust effect on modifier attachment, illustrating the important role this information plays in sentence processing. Although the survey was conducted only in English, the results suggest that differences in overall attachment preference between the languages may owe to the availability of alternative prenominal modifier structures in English that are absent in Spanish. Gilboy et al. (1995) also provide data in support of this claim. They found a stronger local attachment preference in English than in Spanish for items that have alternative structure in English, but not in Spanish (cf. their animate possessive items). For thematic items, for which there are no alternatives in either language, the attachment preferences were much closer. Although they attributed the results to construal, the present experiment suggests that their results, at least in part, may be due to the availability of alternative structures, which we have shown has an effect on this type of survey data.

Second, this pattern of results held equally for PP and RC items. This finding is inconsistent with construal, which predicts a difference in attachment preference for these items, as it makes a

distinction between the attachment of primary and nonprimary phrases. Further, construal makes the wrong predictions for either type of modifier. As construal does not apply to the processing of primary phrases, garden-path theory asserts that our PP items should be attached according to late closure, predicting no differences between our possessive and locative items, which was not the case. Construal also asserts that our RC items should be associated into the current thematic processing domain, predicting the opposite pattern of results: the locative items should have shown more NP2 attachment, as the current thematic processing domain is only NP2, than the possessive items, for which both sites are open.

In summary, the findings of the present experiment, along with the self-paced reading data presented above, suggest that pragmatic information, whether it be felicity of NP modification or availability of alternative structures, exerts a strong influence in constraining cross-linguistic variation and on processing in general. It is also important to note that our interpretation of the data differs from a strict Gricean interpretation in two important ways. First, it is a probabilistic constraint. We do not predict that the mere existence of options is what has an effect; it is their frequency of usage that is important. Second, it is only one of a number of soft constraints. As our self-paced reading data demonstrates, cross-linguistic differences are mediated by the pragmatic context in which they occur.

Conclusions

Green (1990), in addressing controversy related to the universality of Gricean principles, makes an important point about cross-linguistic variation and pragmatics in general. She argues that not only is pragmatic constraint on meaning not specific to particular languages, it is not specific to language at all. As such, cross-linguistic variation should not be random; rather, it should follow predictably from non-linguistic principles. Along these lines, the purpose of this chapter has been to explore the predictable role of pragmatic information in constraining and explaining cross-linguistic differences in sentence processing. The data that we have presented make an important point: *within* each language we see the effect of pragmatic constraint, which is useful in explaining differences *between* languages. Simply noting that, apart from this manipulation, Spanish readers are more likely than English ones to modify more distant NPs is interesting, but it would miss the point of *why* this occurs.

Constraint-based accounts of the sort that we have suggested have been criticized for simply observing ad hoc correlations between frequency and parsing preference (Frazier, 1995). To return to Comrie's distinction, Frazier's critique casts constraint satisfaction as a completely Greenbergian enterprise, merely cataloging statistical patterns without a true theory. On the contrary, as we hope to have illustrated in this chapter, the goal of our enterprise is not simply to characterize the statistical properties of a number of languages; we propose that frequency sensitivity emerges from general processing constraints, and is constrained by various kinds of pragmatic information. In our view, both cross-linguistic similarity and variation emerge from the interaction of the speaker's environment and specific pragmatic properties of the cognitive system.

References

Altmann, G. T. M., & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition*, *30*, 191-238.

Berwick, R. C., & Weinberg, A. (1984). *The grammatical basis of linguistic performance.* Cambridge, MA: MIT Press.

Boland, J. E., Tanenhaus, M. K., & Garnsey, S. M. (1990). Evidence for the immediate use of verb control information in sentence processing. *Journal of Memory and Language*, *29*, 413-432.

Chomsky, N. (1965). *Aspects of the theory of syntax.* Cambridge, MA: MIT Press.

Comrie, B. (1989). *Language universals and linguistic typology* (2nd ed.). Chicago: University of Chicago Press.

Cuetos, F., & Mitchell, D. C. (1988). Cross-linguistic differences in parsing: Restrictions on the use of the Late Closure strategy in Spanish. *Cognition*, *30*, 73-105.

Cuetos, F., Mitchell, D. C., & Corley, M. M. B. (1996). Parsing in different languages. In M. Carreiras, J. García-Albea, & N. Sabastián-Gallés (Eds.), *Language processing in Spanish* (pp. 145-187). Mahwah, NJ: Lawrence Erlbaum Associates.

De Vincenzi, M., & Job, R. (1995). An investigation of late closure: The role of syntax, thematic structure, and pragmatics in initial and final interpretation. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *21*, 1303-1321.

Ferreira, F., & Clifton, C., Jr. (1986). The independence of syntactic processing. *Journal of Memory and Language*, *25*, 348-368.

Frazier, L. (1987). Sentence processing: A tutorial review. In M. Coltheart (Ed.), *Attention and performance XII: The psychology of reading* (pp. 559-586). Hillsdale, NJ: Lawrence Erlbaum Associates.

Frazier, L. (1990). Parsing modifiers: Special-purpose routines in the human sentence processing mechanism? In D. A. Balota, G. B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 303-330). Hillsdale, NJ: Lawrence Erlbaum Associates.

Frazier, L. (1995). Constraint satisfaction as a theory of sentence processing. *Journal of Psycholinguistic Research*, *24*, 437-468.

Frazier, L., & Clifton, C., Jr. (1996). *Construal.* Cambridge, MA: MIT Press.

Frazier, L., & Clifton, C., Jr. (1997). Construal: Overview, motivation and some new evidence. *Journal of Psycholinguistic Research*, *26*, 277-295.

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, *14*, 178-210.

Garnsey, S. M., Pearlmutter, N. J., Myers, E., & Lotocky, M. A. (1997). The relative contributions of verb bias and plausibility to the comprehension of temporarily ambiguous sentences. *Journal of Memory and Language*, *37*, 58-93.

Gibson, E., Pearlmutter, N. J., Canseco-Gonzalez, E., & Hickok, G. (1996). Recency preference in the human sentence processing mechanism. *Cognition*, *59*, 23-59.

Gilboy, E., Sopena, J. M., Clifton, C., Jr., & Frazier, L. (1995). Argument structure and association preferences in Spanish and English complex NPs. *Cognition*, *54*, 131-167.

Gorrell, P. (1989). Establishing the loci of serial and parallel effects in syntactic processing. *Journal of Psycholinguistic Research*, *18*, 61-73.

Green, G. (1990). The universality of Gricean interpretation. In *Proceedings of the Sixteenth Annual Meeting of of the Berkeley Linguistic Society* (pp. 411-428). Berkeley, CA: Berkeley Linguistic Society.

Greenberg, J. H. (1963). Some universals of grammar with particular reference to the order of meaningful elements. In J. H. Greenberg (Ed.), *Universals of language* (pp. 58-90). Cambridge, MA: MIT Press.

Hawkins, J. A. (1991). On (in)definite articles: Implicatures and (un)grammaticality prediction. *Journal of Linguistics*, *27*, 405-442.

Hawkins, J. A. (1994). *A performance theory of order and constituency*. Cambridge, UK: Cambridge University Press.

Juliano, C., & Tanenhaus, M. K. (1994). A constraint-based lexicalist account of the subject/object attachment preference. *Journal of Psycholinguistic Research*, *23*, 459-472.

Kadmon, N. (1990). Uniqueness. *Linguistics and Philosophy*, *13*, 273-324.

MacDonald, M. C. (1994). Probabilistic constraints and syntactic ambiguity resolution. *Language and Cognitive Processes*, *9*, 157-201.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review*, *101*, 676-703.

McRae, K., Spivey-Knowlton, M. J., & Tanenhaus, M. K. (1998). Modeling the influence of thematic fit (and other constraints) in on-line sentence comprehension. *Journal of Memory and Language*, *38*, 283-312.

Mitchell, D. C., Cuetos, F., Corley, M. M. B., & Brysbaert, M. (1995). Exposure-based models of human parsing: Evidence for the use of coarse-grained (non-lexical) statistical records. *Journal of Psycholinguistic Research*, *24*, 469-488.

Pritchett, B. (1988). Garden path phenomena and the grammatical basis of language processing. *Language*, *64*, 539-576.

Rayner, K., Carlson, M., & Frazier, L. (1983). The interaction of syntax and semantics during sentence processing. *Journal of Verbal Learning and Verbal Behavior*, *22*, 358-374.

Spivey-Knowlton, M. J., & Sedivy, J. C. (1995). Resolving attachment ambiguities with multiple constraints. *Cognition*, *55*, 227-267.

Thornton, R., MacDonald, M. C., & Gil, M. (1998). *Pragmatic constraint on the interpretation complex noun phrases in English and Spanish*. Manuscript submitted for publication.

Trueswell, J. C. (1996). The role of lexical frequency in syntactic ambiguity resolution. *Journal of Memory and Language*, *35*, 566-585.

Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic influences on parsing: Use of thematic role information in syntactic disambiguation. *Journal of Memory and Language*, *33*, 285-318.

Weckerly, J., & Elman, J. L. (1992). A PDP approach to processing center-embedded sentences. In *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society* (pp. 414-419). Hillsdale, NJ: Lawrence Erlbaum Associates.